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ECL 243

THE BOUNCING BOTTLE

A housewife is burned on both feet when a bottle of drain cleaner is accidently knocked off a shelf and breaks, releasing its contents of sulfuric acid. A lawsuit is launched against the distributor, but what then?

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Names of all individuals and business organizations have been withheld to protect the innocent (or guilty) by request of the plaintiff's attorney who graciously granted permission to use the information.

THE BOUNCING BOTTLE

Part A

The Circumstances

Mr. & Mrs. Homeowner were having a problem with a partially clogged drain. Mr. H stopped on the way home from work and bought a bottle of drain cleaner. He gave this to his wife with a comment to the effect that if she used it, the problem should end. But Mrs. H wasn't remotely interested in handling the cleaner and told her husband that he could do it. Since it wasn't convenient at the time, the bottle was not opened but was put on a shelf (allegedly about two feet high) in the bathroom. A few days later on 1 November 1970, Mrs. H accidently bumped the bottle from the shelf onto the bathroom floor. The cap of the bottle fractured. The contents (sulfuric acid) came out and burned Mrs. H on the back of both feet.

Mr. & Mrs. H filed suit for damages against the distributor of the drain cleaner. The distributor, in turn, filed suit against his supplier as a third party defendant. This supplier, in turn, filed suit against four of his suppliers as third party defendants.

Observations of Bottle

Some six years after the accident, the top of the bottle in question with its cap appeared as shown in Photograph A1. When the cap was removed, a seal across the mouth of the bottle was found to be partly detached as shown in Photograph A2.

Background Information

The distributor, the primary defendant (D1), marketed the drain cleaner under its own trade name. It purchased the labeled bottle and its contents, ready for distribution and sale, from a supplier.

The supplier (D2) selected the bottles and caps and purchased them from suppliers. D2 filled the 28-fluid-ounce bottles with 66^{o} Baume sulfuric acid (specific gravity = 1.84), then capped, sealed, labeled, and shipped them in cartons to the distributor.

The maker of the bottle (D3) produced the bottle by blow molding from a thermoplastic polymer, namely, a high density polyethylene (specific gravity of 0.955 to 0.960, (ASTM Test method D792) and a melt index of 0.2 to 0.3. Bottle weights were 55 to 60 grams.

D2 raised the question of quality control with D3 about 18 months after the accident and received a letter (Exhibit A1) in reply referring to "cylinder quarts and gallon jugs." The air test on the gallon jugs was: "Each bottle shall withstand a 6 psig pressurization for at least ten seconds without evident loss of pressure on a guage graduated in 1/10 psi segments." The drop

test was: "Containers filled with water and tightly capped shall withstand a minimum 3 foot vertical drop onto a smooth concrete floor without leakage or rupture."

In response to a request from an insurance company executive, the president of D3 responded with the information given in Exhibit A2.

The cap was supplied by one of two companies (D4 and D5). It was later determined that D4 had actually supplied the cap and D5 was released from legal action. The polypropylene cap was injection molded in one piece with integral threads. When supplied to D2, the cap had a liner placed inside.

The liner was supplied by the sixth defendant (D6). Advertising material on this liner is given in Exhibit A3. An exploded view of this liner is also shown in Exhibit A3. Information on the development of this seal is given in Modern Packaging for April 1966, pp 168, 169, 330.

Further Observations

There were a number of messages on the bottle. Among them were: "DANGER - POISON;" "Contains sulfuric acid, causes severe burns, read directions carefully before using;" "Keep out of reach of children;" and "Do not use on aluminum."

A duplicate of the cap in question was available for examination. This had a liner which appeared to be the color of aluminum. This cap was relatively rigid, as the edge could barely be forced "out of round" by squeezing hard between the thumb and forefinger.

A second bottle of drain cleaner was available from the same lot as the bottle in question. When this was examined in October 1976 (about 6 years after the accident), the seal from the liner appeared to be intact. When examined again in April 1977, this seal was no longer intact. The bottle had not been handled or dropped in the meantime except that it had been hand-carried while flying from one city to another.

Questions

1. Critique the adequacy of the design (including selection of materials) for containing sulfuric acid.

2. Critique the adequacy of testing procedures for the bottle.

3. Discuss the suitability of using concentrated sulfuric acid for drain cleaning in household applications.

4. If you find any inadequacies in any of the above, what would you do to eliminate or minimize the inadequacies?

Photograph A1 Top of bottle with cap in place showing T-shaped crack in cap. The circumferential portion of the crack follows one of the threads in the cap.

Photograph A2 Top of bottle with cap removed showing seal attached at left and detached at right. Liner seal was attached over about 1/4 to 1/3 of periphery.

Dear Rege:

In reply to your request of January 14, here is a run-down on what we regard as our specifications for the quality control of the cylinder quarts and gallon jugs we furnish you.

Primarily it is a matter of material specification and process control via weighing the bottles, dimensionally checking the outside diameter of the finishes, and visual inspection. We do 100% air-test the gallon jugs.

Destructive tests, such as cutting to measure wall thickness and drop test, are usually only conducted at the start up of a run or when we are alerted by appearance or weight variation that something may have gone wrong.

As you know, we run a generally heavier bottle than most people as a matter of insurance.

Though more comprehensive specifications exist among larger users and producers of plastic bottles, my inside contacts so far in the field reveal that most producers are following a similar procedure to our own. Those producers equipped with testing laboratories are running comprehensive tests when they are forced to render reports and encounter AQL lot testing requirements: but this is only loosely tied-in with their manufacturing controls as a practical matter. Otherwise the testing and paperwork costs more than the bottles.

I hope this information will satisfy your need at the present time.

Best regards,

EXHIBIT A1

Letter from the president of the bottle maker (D3) to the chief executive of drain cleaner supplier (D2) about 18 months after the accident.

This will reply to your letter request of February 28th for more information on how we test our bottles for impact strength.

There has been little standardized in the industry beyond a counter-height drop onto a hard surface filled with water should not rupture the bottle.

Obviously, glass bottles could never pass this test.

Most plastic bottle manufacturers periodically perform drop tests filled with water from a 3 or 4 foot height. We use at least 4 feet and at least 3 consecutive drops to satisfy ourselves.

The Clorox Co. calls for a single drop from a 4-foot height for plastic bottles weighing 44 to 46 grams with a sample lot of 22 bottles. If two or less fail, the lot is accepted. If three fail, the test is repeated. If three or more fail the second test, the lot is rejected.

We run our plastic quarts at least 25% to 30% heavier than Clorox as a safety measure. We have no specific AQL program but make much shorter runs than someone like Clorox. Each separate run is checked for impact via our drop test and then controlled by weight. All our bottles are sampled repeatedly on each shift and collected in the laboratory for two days at a time for a series of dimensional and visual checks to insure our process is not wandering. The empty weights are checked hourly night and day.

Enclosed is a polaroid snap of a couple of the quarts which xxxxxx (D2) uses which have passed the three consecutive drops without failure. As you can see, the bottoms have been partially collapsed, but no rupture has occurred.

We are not in a position to conduct these tests filled with acid nor any other product our customers may be filling. We often do not know what our bottles are being used for. This is true throughout our industry.

It is for this among other important reasons that no container manufacturer can or does assume responsibility for the filled performance of his containers.

Not only is it impossible for him to control to zero defects, the container manufacturer loses control entirely of the handling of his product when it leaves his plant.

I hope this information will assist you.

Exhibit A2

Copy of a letter from the president of bottle supplier (D3) to an executive of an insurance carrier for one of the other defendants. Written about 27 months after the accident.

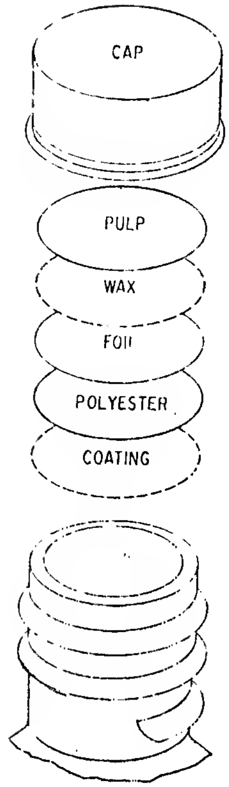

EXHIBIT A3

Information on the liner seal "wafer" and its use in sealing plastic bottles.

CLOSURE LINER MATERIALS for METAL and MOLDED CAPS

PRODUCT INFORMATION

[redacted] Innerseal consists of treated polyester film bonded to a specially treated aluminum foil for use in non-metal caps on plastic containers. This new product provides a hermetic seal, which is uniquely suitable for packaging alkalies, many acids, oils, organic solvents, corrosion inhibitors, powders and pellets. Its use is recommended for products which must be kept free of contamination, oxidation, and moisture. It meets all requirements of the Food & Drug Administration.

Some of the other characteristics provided by [redacted] include a tamper-proof seal, exceptionally high impact and bursting strength, and unusual chemical resistance.

[redacted] is punched into the non-metal cap in the normal method. After being applied to the plastic container, the cap is heated by an induction coil.* This heat causes the sealing medium to fuse the aluminum over the mouth of the container. No adhesive is required. The [redacted] remains on the plastic container upon removal of the cap, while the waxed pulpboard primary liner remains in the cap. The innerseal must be destroyed to remove contents from the container.

*(e.g. Pat. Nos. 2,620,939; 2,799,981; 2,937,481)

Physical Properties

COLOR:	Aluminum
THICKNESS:	.003"
WIDTH:	40" ± 1/16"
WATER VAPOR PERMEABILITY:	Essentially zero. Always lower than the container.
AIR PERMEABILITY:	Essentially zero. Always lower than the container.
OXYGEN PERMEABILITY:	Essentially zero. Always lower than the container.
CO_2 PERMEABILITY:	Essentially zero. Always lower than the container.
WATER ABSORPTION:	Negligible
COMPONENTS:	.002" Treated Polyester Film .001" Treated Aluminum Foil

THE BOUNCING BOTTLE

Part B

Design Adequacy

A drop from a height of 3 feet represents a speed of about 10 inch/minute on contact. Contact speeds of 2000 to 10,000 in/min are usually considered impact conditions. The accident conditions, an alleged drop of two feet, thus indicate an impact of the bottle upon striking the bathroom floor.

What are impact properties of polyethylene and polypropylene? Data are available in many places. For example, Metal Progress (Data issue) for Mid-June 1976 indicates an Izod impact strength (ASTM Test Method D256) for high density polyethylene of 1 to 5 with 0.4 to 1.5 for polypropylene homopolymers.

In a legal situation, however, a question is more likely to relate to information at the time of design and/or manufacture than current information. One set of data available in 1961 is given in Exhibit B1. The effect of notches and temperature on the impact behavior of polypropylene homopolymer is shown in Exhibit B2.

There was no evidence of failure of any kind in the polyethylene bottle but there clearly was failure of the cap.

In view of the above data, it appears that the choice of polypropylene for the molded cap was a poor one.

With regard to other characteristics of polyethylene and polypropylene, such as strength, resistance to sulfuric acid, etc., the choice of materials appears to have been reasonable.

It also appears that the procedure for putting a seal across the mouth of the bottle is reasonable. There is some question about the suitability of aluminum foil in the "wafer" since aluminum is not resistant to attack by sulfuric acid. This apparently was of some concern since D2 had raised a question about lead foil with D5.

The seal on this specific bottle ruptured, at least on dropping and rupture of the cap, if not before. There is no way of determining if the seal had ruptured before dropping nor of determining the specific cause of seal rupture. It is foreseeable that a few will be inferior on a purely statistical basis.

Test Adequacy

The testing methods seem to be marginal. There was no evidence of any kind that the "quart" bottles used in this application were pressure tested

in the same manner as the gallon jugs. Drop testing was done using bottles filled with water. A drop of 4 feet for a water-filled bottle is equivalent to a drop of only 2¼ feet for an acid-filled bottle. This hardly seems sufficient. Dropping water-filled bottles from heights greater than 4 feet would seem to be in order. Some comparisons of impact speed and impact energy are given in Exhibit B3.

There is no evidence that impact testing of the caps was considered. This seems to be an obvious oversight or omission. It is foreseeable that filled bottles might be accidentally dropped or knocked from a shelf. In such an event, there certainly is some significant probability that impact will be on the cap rather than on the bottle. Some sort of impact testing of caps might have led to rejection of polypropylene caps in this application.

Use of Sulfuric Acid

It is generally recognized that it is sometimes difficult to clear clogged drains as a great variety of materials such as hair, soap, etc. may be the problem. If chemical means are used, a relatively powerful chemical may be required. There is no question that concentrated sulfuric acid is relatively and sufficiently powerful. But does one need such a powerful agent? Perhaps not. There is evidence that sodium hydroxide in a maximum concentration of 25% is at least equally acceptable.

It appears that it will clear a clogged drain as effectively as concentrated sulfuric acid. There is one additional aspect worth noting. In the event of a spill on humans (or animals), if NaOH is washed off with water within about 20 to 30 seconds, there is little or no burn damage. With sulfuric acid, on the other hand, there is always some burn damage no matter how rapidly washing with water is done.

Redesign

The possibility of dropping a bottle (or a bottle being accidentally knocked off a shelf) is highly foreseeable. This should have been considered in design or selection of materials for bottle and cap. The relatively low resistance of polypropylene to impact, especially if there were notches such as threads, should have been known.

Selection of a cap material of greater impact resistance might have avoided the problem. Ogorkiewicz (Exhibit B2) indicates that incorporation of small amounts of polyethylene (thus making it a copolymer) will result in considerable improvement in impact behavior. Obviously, selection of some other material (e.g., an unfilled polycarbonate) is an other option.

Improved and more extensive testing procedures should have given a better choice of cap material.

Extended discussions and many data pertinent to containers and closures (including the specific application in this case) are available in Modern Packaging Encyclopedia for 1966. These are specifically pertinent as they indicate the "state of the art" at the time of design of the bottle and cap.

Comments

The plaintiff purchased the drain cleaner directly from the distributor and entered suit against him only. Since the distributor played no part in the design or fabrication of the container and cap, be believed his supplier was responsible. That supplier, in turn, believed some of his suppliers must be responsible. The multiple suit, involving several third party defendants, is not uncommon. It is often the situation when a defendant believes he is not at fault and/or seeks to minimize potential payments by entering suit against suppliers who might be found responsible for part (or all) of any damages.

With respect to the issue of liability, the defense argued that this was a matter of misuse of the product. The plaintiff agreed that the situation was one of unintended use. The plaintiff argued that, if this were a matter of misuse, it was a matter of foreseeable misuse.

This case was settled out of court with payments to the plaintiff made as follows:

Defendant	Position or role	Percent of settlement
D1	Distributor under own label	13 1/3
D2	Supplier/bottler	33 1/3
D3	Bottle maker	- - -
D4	Cap maker	33 1/3
D6	Seal supplier	20

TABLE 8-1. PROPERTIES OF POLYPROPYLENE AND REPRESENTATIVE POLYETHYLENES

Properties	Isotactic polypropylene	Polyethylene	
		Low-density	High-density
Physical properties:			
Specific gravity (68°F)	0.90–0.91	0.914–0.925	0.940–0.965
Tensile strength ×1,000 psi	4.3–5.7	1.5–2.4	2.5–5.0
Elongation (total), %	500–700	400–700	10–300
Yield strength, ×1,000 psi	4.3–4.9	1.1–1.7	2.5–5.0
Elongation (at yield), %	10–20	20–40	5–10
Stiffness in flexure, ×1,000 psi	114–170	18–21	57–93
Impact strength, Izod	0.6–2.5	>16	1.5–12
Hardness (Rockwell)	R85–95	....	R30–50
Thermal properties:			
Melt index, g/10 min	6–20	0.15–200	0.15–8.0
Melting point, °F	329–338	225–235	255–265
Softening point, °F:			
5-kg load	>185	....	180–190
1-kg load	>284	185–195	250–255
Brittleness temperature, °F	<14	−105	−105
Specific heat, Btu/(lb)(°F)	0.46	0.55	0.55
Coefficient of thermal expansion, per °F	62×10^{-6}	83×10^{-6}	$56\text{–}58 \times 10^{-6}$
Electrical properties:			
Dielectric strength (1/8 in.), volts/mil	770–820	480	480
Dielectric constant (10^6 cps)	2.0–2.1	2.3	2.3
Dissipation factor (10^6 cps)	0.0002–0.0003	<0.005	<0.005
Volume resistivity, ohm-cm	$>10^{16}$	$>10^{15}$	$>10^{15}$

EXHIBIT B1

Table of data taken from "Polymeric Materials" by C. C. Winding and G. D. Hiatt, McGraw-Hill Book Co., 1961. Pages 278 to 291 give a detailed discussion of polyethylene and polypropylene.

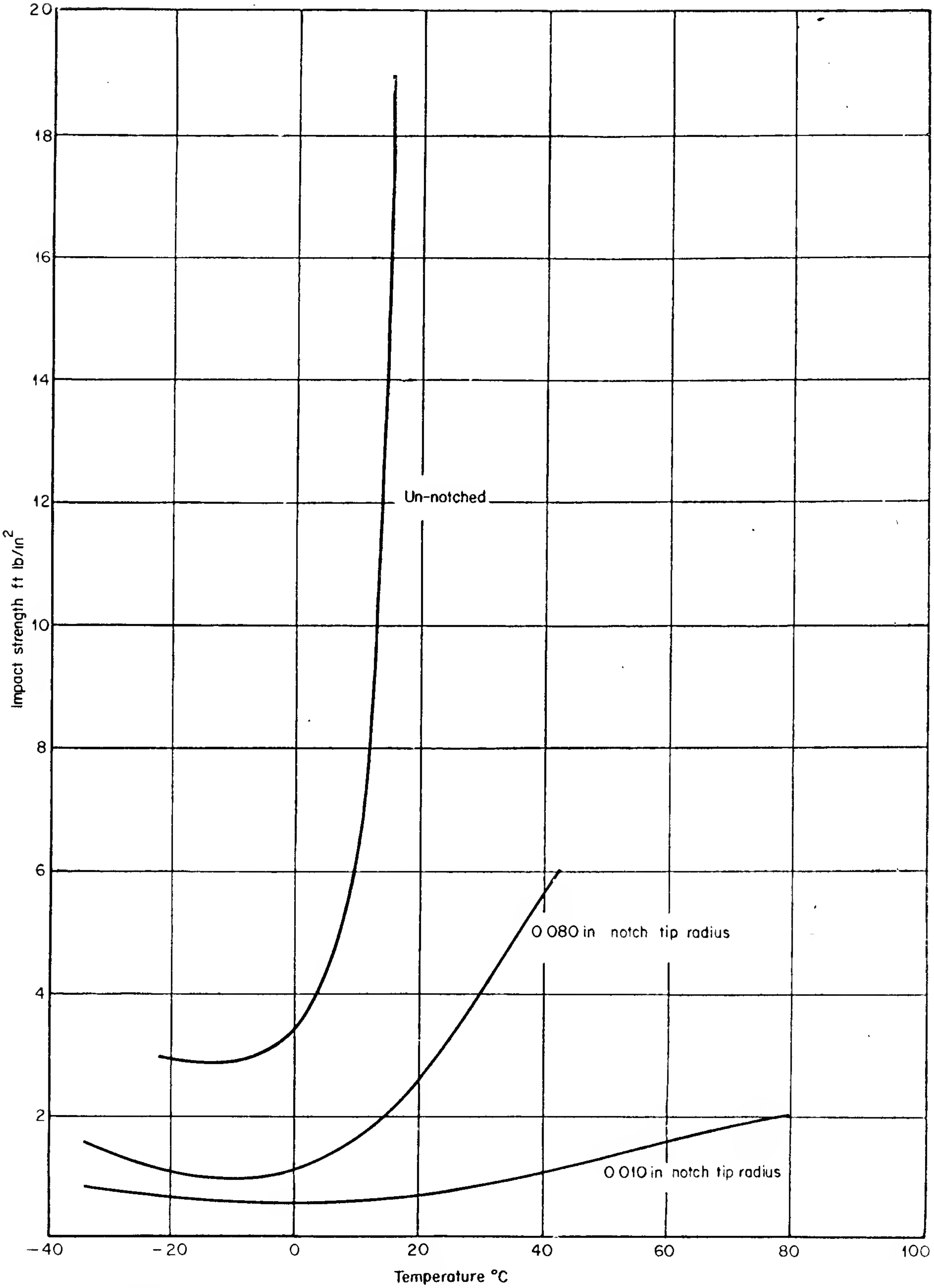

Figure 7.17. Impact strength vs temperature. Propylene homopolymer ('Propathene' GWM 22)

EXHIBIT B2 --- Figure taken from "Engineering Properties of Thermoplastics", edited by R. M. Ogorkiewicz, John Wiley & Son, 1970

EXHIBIT B3

Impact Speeds and Impact Energies

Drop Height, feet	Speed at Impact inch/min	Speed at Impact feet/sec	Speed at Impact miles/hr	Impact Energy*, ft-lb water filled	Impact Energy*, ft-lb acid filled
1	5800	8.0	5.5	1.9	3.4
2	8200	11.4	7.7	3.8	6.7
3	10,000	13.9	9.5	5.6	10.0
4	11,600	16.0	10.9	7.5	13.4
5	13,000	18.0	12.2	9.4	16.7
6	14,200	19.7	13.4	11.2	20.0

* bottle capacity, 28 fluid ounces